Source Aperture Mapper PDR

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Abstract

The Code 920.1 CF calibration transfer instrument uses an integrating sphere input, which has a cosine response. The instrument input and source apertures are used to define the field of view, which inherently integrates any inconsistencies in source output. Because of optics or apertures, other instrument types have an intrinsic a field of view, and assume that the source is uniform. This difference in field of view determination may lead to calibration inconsistencies when two different instruments are used on the same source. To reduce this inconsistency, the source output uniformity must be measured, mapped and introduced into the radiance calculations. A Source Aperture Mapper (SAM) instrument is needed to measure and map the relative radiance non-uniformity across a source aperture. This document describes the preliminary design of a SAM for laboratory use.

Goals

1. Measure radiance as a function of displacement from the source axis.

System Requirements

Parameter	Requirement	Approach
Positioning Resolution	< ±2 mm linear < 0.1° rotational	Position encoder on each axis. Distance sensors for SAM – Source relationship
Speed	< 1 hr to map a 100cm^2 area	Use stepper motors with adequate torque/speed Use FRMS to measure all samples
Spectral Samples	Multiple	Use FRMS, including 12-position filter wheel, each filter being a sample.
Robust	Maximize	Modular design GPIB instrument interconnections
Automation	Maximize	Computer-based motion control Extensive housekeeping & data recording
Upgradeable	Possible	Modular design GPIB instrument interconnections
Cost	Minimize	Use an existing horizontal-vertical translation stage Use presently owned stepper motor systems Use FRMS Engineering Model as detector head Use SSF as software foundation Modular hardware and software design.

Heritage

All SAM components are being used elsewhere in the CF. The FRMS Engineering Model will be used as the detector head for SAM. Motion control systems are identical to those used in the FRMS, HX, and the remanufactured 746/750. Software for SAM is an extension of the SSF. An existing translation stage will be refurbished and reused, primarily for cost and time savings.

System Concept

A detector head is moved in a plane parallel to the source aperture, mapping uniformity along an axis perpendicular to the aperture plane. The head may also be mounted on a tilt/rotation stage for off-axis measurements. The head will contain filters so that the aperture may be mapped at multiple wavelengths.

Optical

SAM will use the Filter Radiometer Monitoring System (FRMS) Engineering Model as the detector head. Refer to the FRMS PDR for details.

Mechanical

The CF presently owns a large horizontal and vertical translation stage, suitable for laboratory use (see Figure 1). Lead screws and ball nuts are used to transfer rotary motion to linear motion. The vertical stage is gravity pre-loaded. A constant force spring will be added to pre-load the horizontal stage.

Figure 1 - SAM Translation Stage

Stepper motors will drive the lead screws. Linear position encoders, one attached to the vertical stage, the other attached to the platform (see Figure 2), will be used as stepper motor feedback to achieve precise, repeatable positioning.

A tilt/rotation stage may be added at a later time to permit off-axis (not perpendicular to the aperture plane) measurements. If necessary, this is accomplished by fixing the detector head to the desired tilt and rotation angles.

Jackscrews will be used to level SAM. A cross level mounted on the platform will be used to ensure SAM is level and plumb.

Precise, repeatable positioning of SAM relative to the source aperture will be achieved by using optical distance sensors in a differential mode. When the measurement difference is zero, the SAM motion plane is parallel to the source aperture.

To simplify component mounting, a pattern of 1/4-20 and through holes on 1/2" centers will be added to the platform. This pattern is compatible with standard optical table hole patterns, enabling use of COTS optical components. One such component is a tilt/rotation stage, permitting off-axis measurement capability.

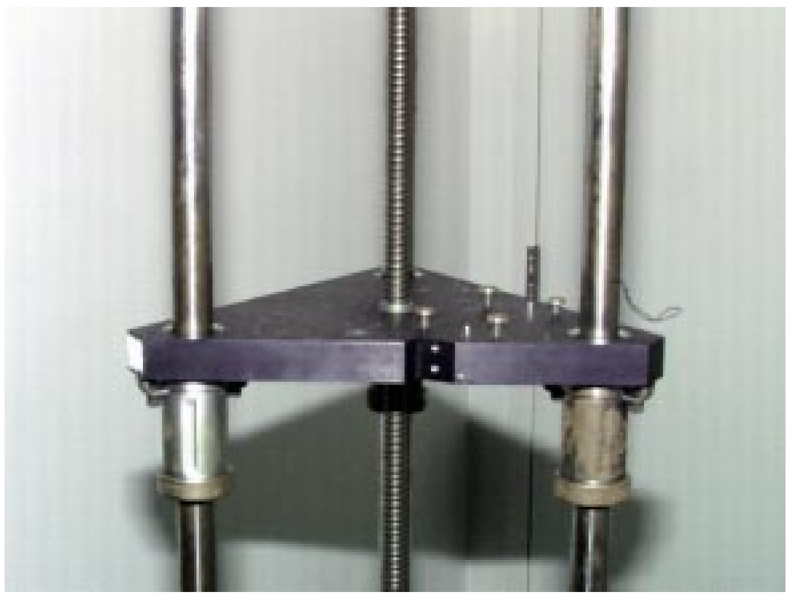

Figure 2 – SAM Vertical Platform

Horizontal and vertical positioning stepper motor controllers are mounted near the stepper motors. Stepper motor power supplies are mounted in the recess beneath the horizontal translation stage.

Tilt/rotation stage stepper motors are integral with the tilt/rotation stage. Tilt/rotation controllers are mounted on the platform near the stage, power supplies being mounted in the recess beneath the horizontal translation stage.

Electrical

The translation and tilt/rotation stages motion is generated by stepper motors. The stepper motor controllers are connected by RS422 (in multi-drop mode) to one GPIB – RS422 converter, which supports all stepper motor controllers. This permits easy integration into the existing GPIB environment connected to the Macintosh control computer (see Figure 3). Though not initially present, the tilt/rotation stage motion control is easily added at a later time.

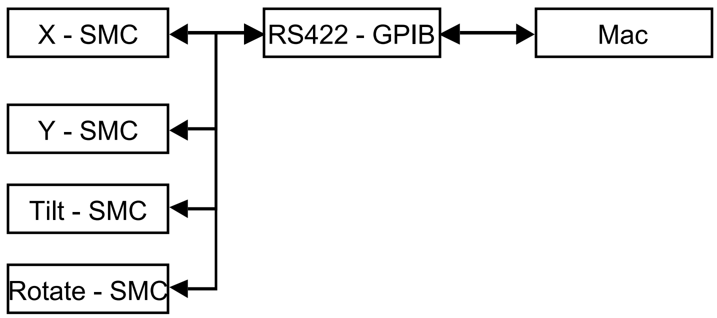

Figure 3 - SAM Electrical Block Diagram

SAM uses the FRMS Engineering Model as its detector head. As such, the above components are in addition to the FRMS electronics. Please refer to the FRMS documentation for details.

Software

Function

SAM software will be built on the SSF. Two modules are required: one to position the head, the second to format and record the aperture mapping data. The positioning module will leverage off the module used for the FRMS filter position. The aperture map module is a data processing module which uses the FRMS data as an input, and generates an aperture map.

Data Collected

Each SAM sample consists of position (tilt, rotation, horizontal, and vertical) and an FRMS data set, consisting of 12 wavelength measurements. The SAM sample set size will vary due to aperture size and resolution settings. This sample set will be processed into uniformity maps by normalizing each wavelength over the horizontal and vertical positions for each of the tilt and rotation angles.

Data Storage & Dissemination

Raw and processed aperture map data are stored as binary files. These files will be available for download through the CF web site, *http://spectral.gsfc.nasa.gov/*. The uniformity map images will be available on the same web site for viewing.

Operation

SAM is positioned near the aperture to be mapped. Jackscrews are adjusted until SAM is level and plumb. SAM is coarsely adjusted so the detector head input clears the aperture. The distance is finely adjusted until the distance sensor difference nears zero. SAM is manually positioned so the detector head is near the aperture center.

The SAM software will determine the approximate dimensions of the aperture, and will then proceed to map the aperture. The aperture will be overscanned, ensuring a complete mapping of the aperture.

Mapping is accomplished by positioning the translation stages, waiting for any mechanical oscillations to settle, then sampling all FRMS wavelengths for that position. If the tilt/rotation stage is installed, the head is then positioned to the next position, and all FRMS wavelengths are again sampled. This process is repeated for each tilt/rotation then aperture position.

Calibration

SAM does not require calibration, since all measurements are relative.

Cost

Estimated component cost to complete SAM, in the basic configuration, is $4250 ±10%, with the following cost breakdown:

Fabrication	$1000
Linear Position Encoders & Electronics	$3000
Electrical & Electronic Components	$250

The above cost does not reflect the cost of components already in CF inventory.

Upgrading SAM to include off-axis measurements will require the addition of a computer controllable tilt & rotate stage. Estimated cost for this upgrade is $2000 ±10%.

Schedule & Manpower

Completion to a basic operational state is about 9 weeks. Projected start date is early Dec 1999. Schedule breakdown follows:

Bracket design	1 MW
Fabrication	3 MW*
Component procurement	6 MW*
Programming	3 MW*
Integration & Test	2 MW
	* In parallel
	MW = Man Week